the binder course and 35 to 45 cents per square yard for the wearing course, or a total of 65 to 80 cents per square yard. These costs vary somewhat in different localities, because of the proximity of local materials or variance in freight rates. For the resurfacing described above, where only 100 to 110 pounds per square yard of bituminous-coated aggregate were used as a binder course and 12 to 15 pounds per square yard of rock asphalt were used as a wearing course, the cost for the total resurfacing was a little under 30 cents per square yard.

In this paper, I have described several methods which have been used in resurfacing state highways within the past few years; and from our experience with such resurfacing, I wish to emphasize some of the main points that I believe should be carefully considered.

1. Consider the amount and kind of traffic that is to use the road.
2. Consider carefully the strength of the old pavement to be resurfaced.
3. Look into the availability and cost of possible resurfacing materials.

With these data at hand one can better design the proper section to be used in such resurfacing.

Many miles of pavement have been constructed within the past few years. When these pavements have worn to such an extent that maintenance costs begin to mount, it is economy to resurface them. Bituminous mixtures lend themselves very readily to that work and present probably the most economical method of handling the problem.

RESURFACING ROUGH PAVEMENTS WITH THIN LAYERS OF BITUMINOUS MIXTURES

By Earl B. Lockridge, District Engineer, Indiana State Highway Commission, LaPorte, Indiana

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The resurfacing of rough pavements with thin layers of bituminous mixtures is a subject of increasing importance as our older pavements begin to show signs of failure, wear, or disarrangement as result of increasing loads and action of the elements. This is of greater concern to the city official, responsible for the maintenance of streets, than it is to county and state highway officials.

Resurfacing of rough pavements has a further appeal at this particular time because of the strained financial condition of the country at large and the resulting inability of the taxpaying public to finance reconstruction. In other words, the

public official finds it necessary to face this problem in about the same manner as an individual with a pair of shoes in good condition, except that the heels are run down and the soles are wearing through. The thrifty person will ordinarily have shoes reconditioned, and that is especially true at a time when funds are coming hard. So the public official finds it proper to put a "half-sole" on pavements that are rough or in distress, building up additional strength in spots that are failing because of unstable or insufficient base.

When we have decided upon the necessity and advisability of reconditioning the surface of an old pavement, the next problem to be solved is "What material will adapt itself in the most practical and economical way to the job at hand?" There are a number of different materials or combination of materials on the market today that might be used. Each material has its own peculiar qualities that should be taken into consideration along with cost, availability, and future maintenance in determining just what material and means of resurfacing should be utilized.

SOME PRACTICAL EXAMPLES

About two years ago we began receiving numerous complaints about the rough condition of an old brick street in Bourbon traversed by U. S. Route 30. We learned that this pavement had been constructed in 1912 according to the usual practice of the time, and most certainly had not been designed to carry modern automotive and more particularly truck traffic. A modern concrete pavement had been constructed across our state connecting Fort Wayne and points east in Ohio with Chicago, thereby leading a very great quantity and large variety of traffic over this brick street. Strange as it may seem, this old pavement, designed largely for horsedrawn traffic and maximum loads of less than one-fourth the weight of average truck loads passing over it today, was standing up very well except that the suction from inflated tires was removing the joint filler and that at a few spots the earth base was giving way, which caused a more or less rough riding surface throughout. The surface was warped at points of settlement, with now and then a rather abrupt unevenness.

Repairs consisted in first patching the spots of greatest unevenness with bituminous-coated aggregate, after which the entire surface (.43 mile, 24 and 26 feet wide) was cleaned and given a light treatment of emulsified bitumen (about 0.2 gallon per square yard). Bituminous-coated aggregate was dumped on this prepared surface and then spread and leveled to a depth of 2 inches by the use of grader and maintainer. The leveling process by the use of maintainer continued as the material was compacted with a light, homemade roller drawn by a small tractor. After the bituminous-coated material had

sufficiently cured and become stabilized with a suitable cross section, through the planing and rolling process, the entire surface was thoroughly cleaned and given a treatment of about 0.3 gallon of emulsified asphalt per square yard. This treatment was followed with a light application of comparatively fine covering material which was broomed into place as needed to fill the voids of more open spots or take up any surplus bituminous material.

This street had a curb and gutter apron which fitted the original cross section; so to avoid complications, we allowed our "half sole" to feather out on either side some 2 or 3 feet from the gutter apron edge. At present the casual observer would not know that the original plan had not contemplated this resurfacing. Except for two blocks where there was a convenient detour, traffic was allowed use of this pavement throughout, our forces handling one side at a time.

This improvement has added strength to and made a good riding surface out of an old brick street, thereby doing away with a certain amount of impact and vibration which would ultimately have meant destruction. The entire job was completed in two weeks with comparatively no inconvenience to travel. The maintenance cost on this portion compares favorably with that of the concrete on either side of Bourbon, and I see no reason why this surface will not continue to carry traffic as at present. This entire cost amounted to 41 cents per square yard of surface.

Perhaps the biggest piece of resurfacing work undertaken by our maintenance forces in the northwestern part of the state was the reconditioning of a portion of the Dunes Highway (U. S. Road 12) in Lake and Porter counties. This pavement was constructed of reinforced cement concrete in 1922-23 to a width of 20 feet and was largely over new location varying from muck to sand. In order to get a suitable grade of sufficient elevation to be clear of water during extreme wet periods, it was necessary to introduce a considerable quantity of special borrow fill. To accomplish this fill, drag line equipment was used and a ditch of considerable size and depth was dug along the south side of and parallel with the roadway, and so close that its slope coincided with the outer slope of the berm.

Naturally, this pavement began to get out of shape shortly after being opened to traffic. The amount of settlement and the warped condition was accelerated with the ever-increasing volume and character of traffic. Also, some local drainage work lowered the water table, which caused the muck to shrink quite noticebly.

On account of the unusual volume of traffic on the Dunes Highway, which on peak days reaches 14,500 vehicles in 24 hours, the maintenance division constructed a 4-foot metal

berm along each edge of the slab several years ago and has since maintained it by light applications of bituminous material.

From Miller easterly, 2.29 miles of this pavement became so distorted as to be dangerous to fast-moving vehicles. There were extreme settlements of as much as 22 inches and the south half of the pavement along the borrow pit was invariably several inches lower than the other side. The settlements were not continuous or uniform, thus producing a series of dips and waves much like the lay-out of a roller-coaster track. It was first necessary to haul in several thousand yards of fill material and build up the berms, at places of settlement, to the elevation desired for re-established pavement surface. Then we patched out the greater depressions with waterbound macadam to the full width of 28 feet. Many of the patches were too deep to be handled as one course and, had there been anything other than sand for fill material, it would have been economy to have placed a layer of earth over the pavement under the waterbinding to save stone. We used a large quantity of stone and secured a reasonably smooth surface, feathering out at edges of waterbinding and dressing out slight depressions in the pavement with a binder course of asphaltic macadam.

This entire surface was then given a treatment of liquid asphalt (about 0.4 gallon per square yard), after which a 2-inch wearing course of asphaltic concrete was placed. We used, on the greatest portion of this improvement, a hot-mixed material laid hot, which our specifications contemplated should have machine finish. Because of the unusual width and the trouble that would have been encountered with loose sand berms, we spread and finished this surface by hand. A small portion of this surface was made from asphaltic concrete mixture (Colprovia) which is a hot mix laid cold. We also used a small amount of the Colprovia mixture to plane into the surface of the asphaltic concrete, since we had specified a rather open mix in order to have a more non-skid surface. The depressions in the old pavement were so great that even though there were many bare spots where we placed no waterbinding at all, the amount of stone used amounted to an average of 4.28 inches loose throughout. The bituminous material including binder course used in patching and that planed into the wearing surface, averaged 2.07 inches loose throughout. The surface charge on this entire improvement amounted to 88 cents per square yard, 46 cents of which was for the wearing surface.

Another job of resurfacing, small but interesting, was an old cement concrete pavement just west of South Bend on Road 2, formerly U. S. Road 20, commonly known as Division Street Road. An unusually bad condition developed on 1,400

feet, due largely to unstable base, resulting in the slab breaking badly and shifting out of position. At first our maintenance forces repaired the worst places with patches of cold mix material, but last season we decided that we were not keeping up with the destructive elements; so we placed a wearing surface over the entire width of 20 feet, first patching out the worst unevenness with a binder mix. This job was small and because of the considerable amount of material used in patching averaged a 3-inch loose course throughout, making a cost of about 83 cents per square yard. Bituminous concrete (Colprovia) was used.

We have resurfaced a number of old macadam roads with more or less heavy construction ranging from 3-inch retread course to 4-inch bituminous macadam with ¾-inch rock asphalt wearing course. As previously stated, each particular job should be a study of its own, resulting in the selection of a material that will meet the several requirements involved.

Late last fall we placed 1,300 feet of 22-foot wearing surface on an oil mat using three different materials. These materials were: rock asphalt, synthetic rock asphalt (Crown Rock), and bituminous concrete (Colprovia), all laid cold and capable of being luted and planed. So far there is no apparent difference in results from these three materials, but by observing their future behavior we hope to learn more about their uses.

ENGINEERING REQUIRED IN IMPROVEMENT OF NEWLY ABSORBED TOWNSHIP ROADS

By M. T. Madden, Daviess County Surveyor

The subject assigned me is of much concern to the people who live in the rural districts, particularly to those who live alongside the many unimproved earth roads of the township which have been, since last September, under the control and management of the county commissioners and county highway superintendent. No doubt, the legislators in the called session of last year had many reasons for enacting the law giving to the county commissioners the care and responsibilities of the township roads. They probably had in mind greater possibilities for the betterment of the condition of those roads by relieving the township trustees of such responsibility and giving the task to a more powerful unit, a unit that has been strengthening itself for a number of years in the process of maintenance of the improved roads of the county. The county highway department has become well organized and by the use of modern power-operated equipment in the maintenance of the many improved roads, has accomplished much.